Ultra-high Fidelity Controller Hardware-in-the-Loop (cHIL) Nanosecond resolution “flight simulator” for future grid

Typhoon HIL, Inc
Grid is becoming highly dynamic. **Power electronics systems** are driving the change.
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Grid is an emerging **cyber-physical** system: smart inverters, distributed generation, micro-grids, distributed storage coupled with distributed control and communication.
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**Complexity** of the cyber-physical system is driving the need for new test tools/methods.
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**Complexity** of the cyber-physical system is driving the need for new test tools/methods.

Real-time Controller **Hardware-in-the-loop** (cHIL) simulation is becoming ubiquitous in power electronics and power systems.
Standard picture of the power grid
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Emerging cyber-physical power grid
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Approaches to control and communication testing in cyber-physical systems
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Simulation

Controller HIL

Power HIL

Complete System
Approaches to control and communication testing in cyber-physical systems

Simulation

Controller HIL

Power HIL

Complete System
Approaches to control and communication testing in cyber-physical systems

Simulation

- Inv
- G
- C
- C
- DMS
- µC

Controller HIL

- Inv
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- C
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- DMS
- µC

Power HIL

- Inv
- G
- C
- C
- µC

Complete System

- Inv
- G
- C
- C
- DMS

Cost

- fidelity

Flexibility
Approaches to control and communication testing in cyber-physical systems

Simulation
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Cost
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Simulation

Controller HIL

Power HIL

Complete System

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Controller HIL

Physical

Cyber

\( C \) \( \mu C \) \( DMS \)

Inv \ G

Cost

Fidelity

Flexibility
The new way of **TESTING** power electronics **controllers**. The **Controller Hardware-in-the-Loop (cHIL)** way.
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Ultra-high fidelity real-time simulation combined with ease of use is revolutionizing smart inverter testing
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**Ultra-high fidelity**: 20 ns PWM sampling, 0.5-1μs time step.
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Easy to use
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**Ultra-high fidelity**: 20 ns PWM sampling, 0.5-1 μs time step

**Easy to use**

Plug and play interface to industrial controllers (customized)
The new way of TESTING Complete Systems.
The Controller Hardware-in-the-Loop way.
20ns sampling time, and 500ns simulation time step enables finding problems on μs to hours timescales
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Ultra-high fidelity via vertically integrated cHIL solution

OEM Control System

Software

Hardware

PLUG and PLAY

HIL Interface

HIL Software

HIL Hardware

HIL API

Typhoon HIL Solution
cHIL Advantage:
orders of magnitude better test coverage
orders of magnitude lower cost of testing
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Should we be worried about reliability, availability, and stability of power systems?
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- Software is blamed for more major business problems than any other man-made product.
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- Software is blamed for more major business problems than any other man-made product.
- Poor software quality has become one of the most expensive topics in human history: > $150 billion per year in U.S.
Should we be worried about reliability, availability, and stability of power systems?

- Software is blamed for more major business problems than any other man-made product.
- Poor software quality has become one of the most expensive topics in human history: > $150 billion per year in U.S.
- Improving software quality is a key topic for all industries. Power systems included.
Differential analyzer, Vannevar Bush, MIT 1927
Test relentlessly.

Ivan Celanovic, Paul Roege, Dillon Lynch
ivanc@typhoon-hil.com

www.typhoon-hil.com